

# FELDSPAR AND NEPHELINE SYENITE

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Feldspars are the Earth's most abundant mineral group, estimated to constitute 60% of the earth's crust (Kauffman and Van Dyk, 1994). They are aluminum silicate minerals that contain varying proportions of calcium, potassium, and sodium. Nepheline syenite is a light-colored, silica-deficient feldspathic rock made up mostly of sodium and potassium feldspars and nepheline; although not mined in the United States in 2002, it was imported from Canada for use in the glass and ceramic industries.

## Feldspar

In glassmaking, alumina from feldspar improves product hardness, durability, and resistance to chemical corrosion. In ceramics, the alkalis in feldspar (calcium oxide, potassium oxide, and sodium oxide) act as a flux to lower the melting temperature of a mixture; a glassy matrix is formed that bonds together the other components of the system (Roskill Information Services Ltd., 1999, p. 165).

Glass containers continued to be the largest end use of feldspar. In 2002, shipments by U.S. producers of glass containers were slightly higher than in 2001 (U.S. Census Bureau, 2003a§<sup>1</sup>). In the housing and remodeling markets, feldspar was used in glass fiber insulation, sanitaryware, and tile. Housing starts were about 1.7 million, which was about 6% more than in 2001 (U.S. Census Bureau, 2003b§).

**Production.**—U.S. production of marketable feldspar in 2002, using partly estimated data, was about 790,000 metric tons (t) with a value of about \$42.8 million (table 1). Feldspar was mined in seven States, which were, in descending order of output, North Carolina, Virginia, California, Georgia, Oklahoma, Idaho, and South Dakota. North Carolina accounted for about 42% of the total.

Ten companies mined feldspar, 9 of which operated 12 beneficiation plants—4 in North Carolina, 3 in California, and 1 in each of the remaining States listed above (table 3).

Domestic production data for feldspar were collected by the U.S. Geological Survey by means of a voluntary survey. Of the 12 known beneficiation plants, 6 responded by the data closeout date. The six operations represented about 64% of the 2002 production shown in tables 1 and 2. Production for the remaining six operations was estimated from prior-year production levels.

**Consumption.**—Of the feldspar sold or used in the United States, about 67% went into the manufacture of glass, including glass containers and glass fiber. Pottery (including electrical insulators, sanitaryware, tableware, and tile) and other uses, such as fillers, accounted for the remaining 33% (table 4).

The value of total feldspar sold or used in table 4 is higher than the feldspar production value shown in tables 1 and 2. The sold or used value represents the final marketed feldspar product.

The unit value of \$65.27 per metric ton for the "pottery and miscellaneous" category in table 4 is less than the price range for ceramic-grade feldspar in table 5. However, the latter is stated by the publisher to be intended to serve only as a guide.

**World Review.—Canada.**—Avalon Ventures Ltd. continued work on its high-lithium feldspar Separation Rapids project in Kenora, Ontario. Project engineering and feasibility study work focused on process flowsheet design and transportation studies. To further evaluate a new dry process flowsheet, a 5-t ore sample was collected for shipment to a test milling facility. Test work would allow for optimization of the flowsheet and generate more lithium feldspar for market development work and followup ceramic engineering tests. Engineering, design work, and cost benefit analyses on a small-scale plant were in progress (Avalon Ventures Ltd., 2002).

When added to a glass batch, lithium decreases the melting point and viscosity, reducing energy consumption. In ceramics, lithium lowers vitrification temperatures and enables higher green strength and mechanical strength (Industrial Minerals, 2002b).

**Egypt.**—Gippsland Ltd., based in Western Australia, did a feasibility study on its Abu Dabbab tantalum project, 770 kilometers (km) south of Cairo. Although the initial emphasis of the project was on producing tantalum pentoxide, which is a source of tantalum metal used in electronic capacitors, test work also indicated the potential to produce a significant amount of feldspar. The company, therefore, extended the feasibility study to research it more fully. The Italian ceramic industry is a potential market. The deposit would be worked in joint venture under the name Tantalum Egypt Ltd. Gippsland would have a 50% stake, and the other 50% would be held by the Egyptian Geological Survey and Mining Authority, a statutory body of the Egyptian Government (Industrial Minerals, 2002a).

**Poland.**—Domestic reserves of feldspar are said to be limited. Strzeblowski Mineral Mines sold about 88,000 t of feldspar-quartz flours and grits in 2000. The same year, Wroclawskie Mineral Mines sold about 66,000 t of quartz-feldspar powder generated from granite aggregates washing. This latter material contained a high-iron (Fe<sub>2</sub>O<sub>3</sub>) content and was suitable only for the production of red-body tiles. Polish imports of feldspar in 2000 were 82,000 t, largely from the Czech Republic and Finland. The same year, about 33,000 t of nepheline syenite was imported from Norway (Galos, Lewicka, and Wyszomirski, 2002).

The tile sector has experienced several years of growth and advances in technology, such as single firing. A major feature in the market has been the introduction of porcelainized stoneware (gres porcellanato), which has resulted in increased demand for certain

<sup>1</sup>References that include a section mark (§) are found in the Internet References Cited section.  
FELDSPAR AND NEPHELINE SYENITE—2002

clays and feldspar and some decline in the share of traditional whiteware tiles (e.g., earthenware) (Galos, Lewicka, and Wyszomirski, 2002).

About 20 companies were producing tile, the majority of which were located in the Opoczno-Konskie region of central Poland. Opoczno S.A. was the dominant tile producer into the 1990s. However, with increased domestic demand, more than a dozen new tile companies emerged (Galos, Lewicka, and Wyszomirski, 2002).

Poland's demand for tiles was 83 million square meters in 2000, with domestic producers supplying about 45% of the value. Italy and Spain were the other principal suppliers of tile to the Polish market. New factories were slated to increase domestic tile production to around 95 million square meters per year by 2003 (Galos, Lewicka, and Wyszomirski, 2002).

**Outlook.**—Glass containers have continued to be the largest end use of feldspar. Beer is the largest product category for glass containers in the United States and Canada. This has been a growing market, partly because of a continuing shift by brewers from cans to glass. In 2001, glass containers composed 45% of the packaged beer segment in the United States, up from 32% in 1991.

In addition, the introduction of a new category, low-alcohol refreshers, has created a new source of demand for glass containers in the United States and Canada (Grah, 2002).

Production of glass containers in Western Europe increased to 18.4 million metric tons (Mt) in 2001, according to the European Container Glass Federation (FEVE). This was an increase of about 1% from that of the previous year. Germany produced about 4.3 Mt; France, about 3.7 Mt; and Italy, about 3.3 Mt. The tonnage of recycled glass in Western Europe in 2001 was about 8.4 Mt (excluding the Netherlands). Recycling rates varied among countries (Towers, 2002).

Challenges facing the glass container sector in Europe have included overcapacity, rising energy costs, and competition from other packaging types (such as cans and plastic containers). In some outlets, such as in premium-packaged spirits, glass containers have a competitive edge. New technology has enabled the production of lightweight glass containers. Glass producers are relying more on suppliers to provide quality control and tighter specification requirements of raw materials (Burrows, 2002).

Demand in international markets has continued to grow because of various factors, including the conversion of returnable bottles to recyclable glass bottles. Also, there has been growth of several regional wine industries, especially in Australia and Italy (Grah, 2002).

World ceramic tile output in 2000 was an estimated 4.6 billion square meters, according to the Tile Council of America (TCA). Countries with the largest production were China (34%), Italy (14%), Spain (13%), and Brazil (10%). U.S. tile consumption was about 200 million square meters, of which more than 70% was imported, according to the TCA (Daniels, 2002a).

The tile category with the largest U.S. market share is large-form—30 centimeters (cm) by 30 cm (12 inches by 12 inches) and larger—glazed floor tile with water absorption of less than 5%. Demand has been increasing for porcelain tile, both glazed and unglazed, with water absorption of less than 0.5%. These tiles are very dense and strong. Product demand in the high-fashion segment is for ceramic tiles that emulate natural stone products (Daniels, 2002b).

## Nepheline Syenite

In glass and ceramics, nepheline syenite, like feldspar, provides alkalis that act as a flux to lower the melting temperature of a glass or ceramic mixture, prompting faster melting and fuel savings. In glass, nepheline syenite also supplies alumina, which gives increased resistance to scratching and breaking, improved thermal endurance, and increased chemical durability.

Canada and Norway produced nepheline syenite for glass and ceramic use. In Ontario, Canada, Unimin Canada, Ltd. operated two plants at its Blue Mountain deposit, about 175 km northeast of Toronto. Production of marketable nepheline syenite was about 708,000 t in 2000 (British Geological Survey, 2002, p. 300). End-use data in recent years have not been available, but according to Guillet (1994, p. 724), end uses were glass, especially container glass and glass fiber, 70%; ceramic applications, 15%; and pigments and fillers, 15%. According to Bolger (1995, p. 31), an estimated 60% of the output went to U.S. markets, 20% to Canada, and 20% to Europe.

In Norway, North Cape Minerals AS produced nepheline syenite from an underground mine on the arctic island of Stjernoya; output was about 330,000 t in 2000 (British Geological Survey, 2002, p. 300). End-use data have not been available in recent years, but according to Bolger (1995, p. 38), an estimated 70% of the output went to glass manufacturing; 28%, to ceramics; and 2%, to fillers. According to Guillet (1994, p. 725), shipments went to a number of countries, most notably Belgium, France, Germany, and the United Kingdom.

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TABLE 1  
SALIENT FELDSPAR AND NEPHELINE SYENITE STATISTICS<sup>1</sup>

(Metric tons and thousand of dollars unless otherwise specified)

	1998	1999	2000	2001	2002
United States:					
Feldspar:					
Produced <sup>e, 2</sup>	820,000	875,000	790,000	800,000	790,000
Value <sup>e, 2</sup>	40,800	42,700	44,500	44,100	42,800
Exports <sup>3</sup>	13,200	9,880	11,400	5,460	9,590
Value <sup>3</sup>	1,430	1,160	1,490	1,410	1,370
Imports for consumption <sup>3</sup>	6,560	6,840	7,220	6,140	5,450
Value <sup>3</sup>	601	757	726	749	775
Nepheline syenite:					
Imports for consumption <sup>3</sup>	320,000	311,000	356,000	336,000	333,000
Value <sup>3</sup>	24,100	23,200	24,800	24,100	26,100
Consumption, apparent (feldspar plus nepheline syenite) <sup>e, 4</sup>	thousand metric tons				
	1,130	1,180	1,140	1,140	1,120
World, production (feldspar only) <sup>e</sup>	do.	9,330 <sup>r</sup>	9,980 <sup>r</sup>	9,580 <sup>r</sup>	9,870 <sup>r</sup>
					9,750

<sup>e</sup>Estimated. <sup>r</sup>Revised.

<sup>1</sup>Data are rounded to no more than three significant digits.

<sup>2</sup>Includes hand-cobbed feldspar, flotation-concentrate feldspar, feldspar in feldspar-quartz mixtures, and aplite.

<sup>3</sup>Source: U.S. Census Bureau.

<sup>4</sup>Production plus imports minus exports.

TABLE 2  
ESTIMATED FELDSPAR PRODUCTION IN THE UNITED STATES<sup>1</sup>

(Thousand metric tons and thousand dollars)

Year	Flotation concentrate		Other <sup>2</sup>		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
2001	328	19,700	472	24,500	800	44,100
2002	312	16,000	478	26,700	790	42,800

<sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Includes hand-cobbed feldspar, feldspar-quartz mixtures (feldspar content), and aplite; excludes nepheline syenite.

TABLE 3  
PRODUCERS OF FELDSPAR IN 2002

Company	Plant location	Product
APAC Arkansas Inc.	Muskogee, OK	Feldspar-quartz mixture.
PW Gillibrand Co.	Simi Valley, CA	Feldspar-quartz mixture.
Granite Rock Co.	Felton, CA	Do.
K-T Feldspar Corp.	Spruce Pine, NC	Sodium-potassium feldspar; feldspar-quartz mixture.
Oglebay Norton Specialty Minerals Inc.	Kings Mountain, NC	Feldspar-quartz mixture.
Pacer Corp.	Custer, SD	Potassium feldspar.
The Feldspar Corp.	Monticello, GA	Potassium feldspar.
Do.	Spruce Pine, NC	Sodium-potassium feldspar; feldspar-quartz mixture.
Tinton Enterprises Ltd.	Newell, SD (mine)	Do.
Unimin Corp.	Byron, CA	Feldspar-quartz mixture.
Do.	Emmett, ID	Do.
Do.	Spruce Pine, NC	Sodium-potassium feldspar.
U.S. Silica Co.	Montpelier, VA	Aplite.

TABLE 4  
ESTIMATED FELDSPAR SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE<sup>1, 2</sup>

(Thousand metric tons and thousand dollars)

Use	2001		2002	
	Quantity	Value	Quantity	Value
Glass <sup>3</sup>	550	27,400	528	28,200
Pottery and miscellaneous	251	17,100	262	17,100
Total	800	44,500	790	45,300

<sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Includes hand-cobbed feldspar, flotation-concentrate feldspar, feldspar in feldspar-quartz mixtures, and aplite.

<sup>3</sup>Includes container glass, glass fiber, and other glass.

TABLE 5  
PRICES FOR U.S. FELDSPAR, YEAREND 2002

(Dollars per metric ton)

	Price <sup>1</sup>
Ceramic grade:	
170 to 250 mesh, sodium	66-83
200 mesh, potassium	138
Glass grade:	
30 mesh, sodium	44-57
80 mesh, potassium	94-99

<sup>1</sup>Bulk, ex-works, United States.

Source: Industrial Minerals, no. 423, December 2002, p. 70.



TABLE 6  
U.S. EXPORTS OF FELDSPAR, BY COUNTRY<sup>1</sup>

Country	2001		2002	
	Quantity (metric tons)	Value	Quantity (metric tons)	Value
Canada	1,330	\$187,000	1,370	\$183,000
Costa Rica	1,240	166,000	1,860	239,000
Dominican Republic	163	21,800	125	28,200
Italy	1,850	857,000	1,180	264,000
Malaysia	280	69,600	280	57,600
Mexico	219	25,100	475	68,800
Nicaragua	122	16,700	1,260	167,000
Panama	--	--	2,050	145,000
Thailand	80	20,400	--	--
Other	174	50,000	991	214,000
Total	5,460	1,410,000	9,590	1,370,000

-- Zero.

<sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 7  
U.S. IMPORTS FOR CONSUMPTION OF FELDSPAR, BY COUNTRY<sup>1,2</sup>

Country	2001		2002	
	Quantity (metric tons)	Value <sup>3</sup>	Quantity (metric tons)	Value <sup>3</sup>
Mexico	5,980	\$601,000	5,250	\$536,000
Other	162	148,000	192	238,000
Total	6,140	749,000	5,450	775,000

<sup>1</sup>Excludes nepheline syenite, which is listed in table 1.

<sup>2</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>3</sup>Customs value.

Source: U.S. Census Bureau.

TABLE 8  
FELDSPAR: WORLD PRODUCTION, BY COUNTRY<sup>1, 2</sup>

(Metric tons)

Country <sup>3</sup>	1998	1999	2000	2001	2002 <sup>c</sup>
Algeria	7,000 <sup>e</sup>	2,820 <sup>e</sup>	707	233 <sup>r</sup>	200
Argentina	42,468	62,926	61,000 <sup>e</sup>	60,000 <sup>e</sup>	60,000
Australia, includes nepheline syenite <sup>c</sup>	65,500	49,600	50,000	50,000	50,000
Brazil, processed	59,200	97,661 <sup>r, 4</sup>	117,715 <sup>p, r, 4</sup>	105,000 <sup>p, r, 4</sup>	100,000
Bulgaria	36,000	28,000	22,000	23,000 <sup>r</sup>	25,000
Burma <sup>e, 5</sup>	12,000	12,000	12,000	12,000	12,000
Chile	1,460	1,346	2,311	2,867 <sup>r</sup>	2,900
Colombia <sup>c</sup>	55,000	55,000	55,000	55,000	55,000
Cuba	14,400	4,800	6,700	7,000 <sup>e</sup>	7,000
Czech Republic	266,000	244,000	337,000	300,000 <sup>e</sup>	300,000
Ecuador	60,000 <sup>e</sup>	33,142	47,041	37,633 <sup>r</sup>	38,000
Egypt <sup>c</sup>	325,654 <sup>6</sup>	330,000	330,000	300,000	350,000
Ethiopia	5,000 <sup>e</sup>	391	285	310 <sup>e</sup>	310
Finland	40,000 <sup>e</sup>	40,000 <sup>e</sup>	33,200 <sup>r</sup>	34,289 <sup>r</sup>	35,000
France, crude <sup>c</sup>	706,000	638,000	642,000	650,000	650,000
Germany <sup>c</sup>	460,000	450,000	450,000	450,000	450,000
Greece <sup>c</sup>	65,000	78,500	96,000	95,000	95,000
Guatemala	17,248	17,072	17,804	17,000 <sup>e</sup>	17,000
India <sup>c</sup>	104,509 <sup>6</sup>	105,000	110,000	110,000	110,000
Iran	185,709	239,779	200,000 <sup>r, e</sup>	250,000 <sup>e</sup>	250,000
Italy <sup>c</sup>	2,748,000 <sup>6</sup>	2,700,000	2,500,000	2,600,000	2,500,000
Japan <sup>e, 7</sup>	50,000	52,000	52,000	50,000	50,000
Jordan	4,008	1,000	11,112	11,500 <sup>e</sup>	11,500
Kenya	115 <sup>e</sup>	115 <sup>e</sup>	82	73 <sup>r</sup>	75
Korea, Republic of	248,493	409,334	330,417	389,361 <sup>r</sup>	390,000
Macedonia <sup>c</sup>	8,137 <sup>6</sup>	11,000	10,000	10,000	10,000
Madagascar <sup>c</sup>	6	3 <sup>r</sup>	7 <sup>r, 6</sup>	3 <sup>p, r</sup>	3
Malaysia	31,369	26,940	27,000 <sup>e</sup>	27,000 <sup>e</sup>	27,000
Mexico	197,866	262,241	334,439	329,591 <sup>r</sup>	325,000
Morocco	18,332	1,112	6,052 <sup>r</sup>	8,979 <sup>r</sup>	9,000
Nigeria <sup>c</sup>	500	500	600	600	600
Norway <sup>c</sup>	75,000	72,777 <sup>6</sup>	75,000	73,000	75,000
Pakistan	31,191	29,235	43,186	44,000 <sup>e</sup>	45,000
Peru	3,983	1,594	5,642	4,253 <sup>r</sup>	4,500
Philippines	2,938	16,909	3,440	33,122 <sup>r</sup>	30,000
Poland <sup>8</sup>	116,700 <sup>r</sup>	120,100 <sup>r</sup>	165,200 <sup>r</sup>	220,600 <sup>r</sup>	200,000
Portugal	120,000 <sup>e</sup>	114,688	119,837	120,000 <sup>e</sup>	120,000
Romania	37,010	36,635	37,157 <sup>r</sup>	43,047 <sup>r</sup>	40,000
Russia <sup>c</sup>	40,000	45,000	45,000	45,000	45,000
Serbia and Montenegro	4,280	3,453	4,254 <sup>r</sup>	4,000 <sup>r, e</sup>	4,000
Slovakia	--	6,000	6,000	6,000 <sup>e</sup>	6,000
South Africa	56,761	58,986	66,774	66,736	57,197 <sup>6</sup>
Spain, includes pegmatite <sup>c</sup>	430,000	450,000	460,000	450,000	450,000
Sri Lanka	25,274	26,012	28,638	27,438 <sup>r</sup>	27,000
Sweden, salable, crude and ground	45,000	45,000 <sup>e</sup>	35,000 <sup>r</sup>	40,450 <sup>r</sup>	40,000
Thailand	440,288	626,415	542,991	550,000 <sup>e</sup>	540,000
Turkey	1,089,483	1,369,655	1,147,716	1,200,000 <sup>e</sup>	1,200,000
United Kingdom, china stone <sup>c</sup>	3,278 <sup>6</sup>	3,000	2,000	2,000	2,000
United States <sup>c</sup>	820,000	875,000	790,000	800,000	790,000
Uruguay	2,240	1,556	2,493 <sup>r</sup>	1,500 <sup>r</sup>	1,600
Uzbekistan	NA	300	4,300	4,300 <sup>e</sup>	4,300
Venezuela	148,000	125,000	130,000 <sup>r</sup>	142,000 <sup>r</sup>	140,000
Zimbabwe	2,241	2,250 <sup>e</sup>	2,059 <sup>r</sup>	1,055 <sup>r</sup>	800
Total	9,330,000 <sup>r</sup>	9,980,000 <sup>r</sup>	9,580,000 <sup>r</sup>	9,870,000 <sup>r</sup>	9,750,000

See footnotes at end of table.

TABLE 8--Continued  
FELDSPAR: WORLD PRODUCTION, BY COUNTRY<sup>1, 2</sup>

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<sup>e</sup>Estimated. <sup>p</sup>Preliminary. <sup>r</sup>Revised. NA Not available. -- Zero.

<sup>1</sup>World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Table includes data available through April 29, 2003.

<sup>3</sup>In addition to the countries listed, Namibia and the United Arab Emirates may produce feldspar, but output is not officially reported; available general information is inadequate for the formulation of reliable estimates of output levels.

<sup>4</sup>Source: Departamento Nacional de Produção Mineral (DNPM) [Brazilian Bureau of Mines], Mineral Summary 2001, Feldspar, accessed May 13, 2003, at URL <http://www.dnpm.gov.br/dnpgmengl.html>.

<sup>5</sup>Data are for fiscal years beginning April 1 of year stated.

<sup>6</sup>Reported figure.

<sup>7</sup>In addition, the following quantities of aplite ore were produced in metric tons: 1998--310,000 (estimated); 1999--330,000 (reported); 2000--330,000 (estimated); 2001--310,000 (estimated); and 2002--300,000 (estimated).

<sup>8</sup>Of the amounts shown, the dedicated feldspar mine production accounts for only part of total feldspar production.